Starrett®

MODEL 715
ELECTRONIC GAGE AMPLIFIER

OPERATOR'S GUIDE

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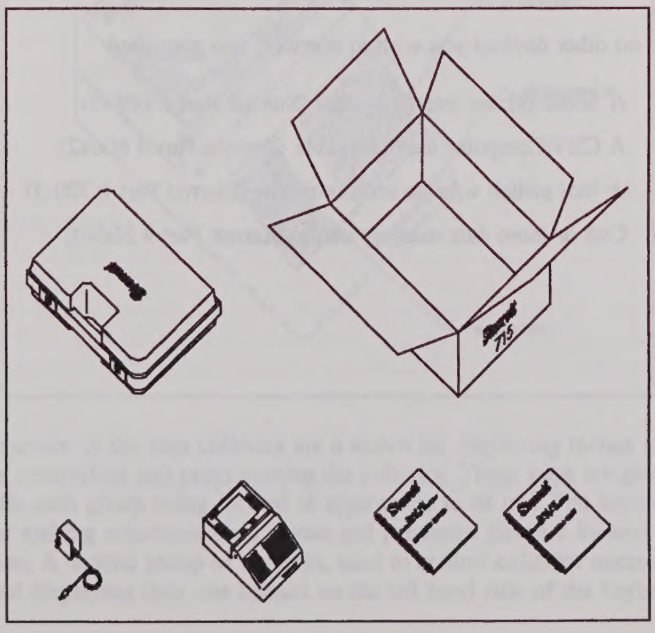
GET READY!

Checking Contents

After removing the package contents, check the items against the parts shown below.



The contents of the package will consist of:

- ☐ The Model 715 Electronic Gage Amplifier
- ☐ A padded carrying/storage case
- ☐ An AC adaptor/battery charger
- ☐ An Operator's Guide
- ☐ A Reference Manual

You will also need one or more probes from the following list:

- ☐ ±.020 Linear probe (Starrett Part # 715-2Z)
- ☐ ±.020 Lever Probe (Starrett Part # 715-1Z)
- ☐ For other ranges and types of probes contact your Starrett dealer

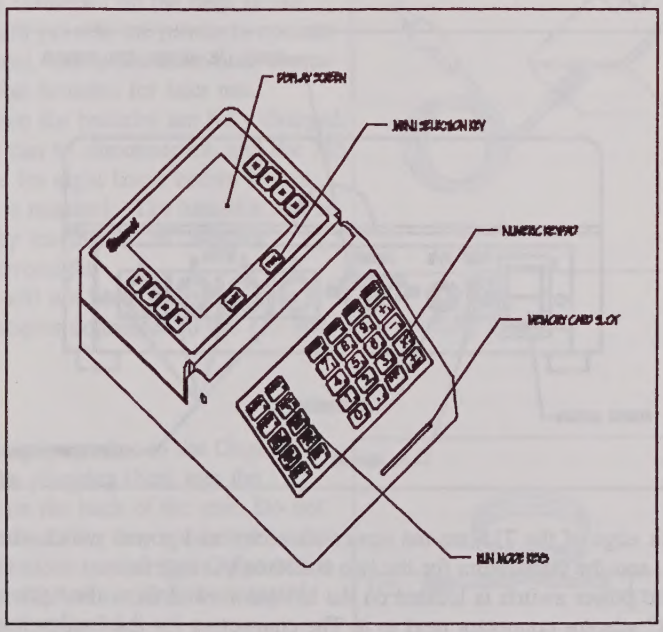
Depending on other devices you wish to connect, you may need

- ☐ A Serial printer interface cable (Starrett Part # 60643)
- ☐ A CRT/Computer interface cable (Starrett Part # 60642)
- ☐ A foot switch w/cable and connector (Starrett Part # 720-3)
- ☐ One or more data memory cards (Starrett Part # 60640)

Getting Acquainted

Take a moment to become familiar with the locations and names of the Gage Amplifier controls and connections.

Front Panel

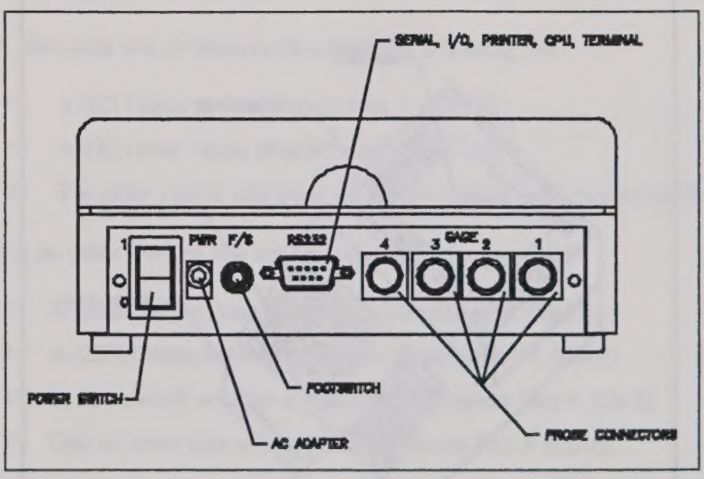


On the top surface of the data collector are a screen for displaying menus and data, and keys for controlling and programming the collector. These keys are grouped by function, with each group being located as appropriate to its use. Ten keys used primarily for making selections from menus and parameter lists are located near the display screen. A second group of ten keys, used to control collector operation while recording and displaying data, are located on the left hand side of the keyboard area on

the body of the collector. A twenty-key numeric keypad, whose primarily function is data and description entry, is located on the right hand side of the keyboard area on the body of the collector.

On the front edge of the data collector is a slot for plugging in 64K byte RAM memory cards. The 715 uses these cards to save and reload part and characteristic data, allowing rapid setup for test operations.

Rear Connections

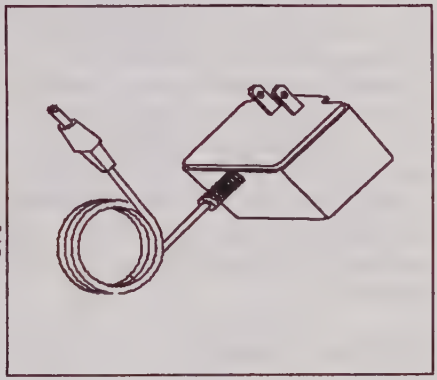


On the back edge of the 715 are the power connector and power switch, the probe connectors, and the connectors for the two collector I/O interfaces.

The power switch is located on the left (as viewed from the back of the case), with the AC adaptor connector next to it. The connectors for the four probes are at the right, with the connector for probe #1 nearest the edge of the case. The two I/O interface connectors are in between. One is a foot switch connector, located on the left, next to the AC adaptor connector; the other an RS232 serial data port, located to its right, next to the probe inputs.

Setting Up

Power

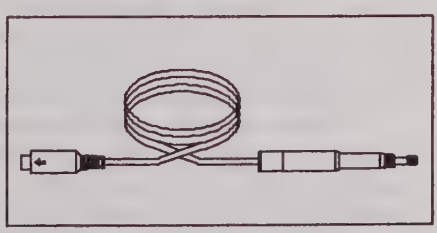


Plug the transformer end of the AC adapter into a 115V outlet, and the small connector at the other end of the adapter cable into the AC adaptor connector on the back of the 715. This will provide the power to operate the instrument, and at the same time charge up its internal batteries for later use.

Once the batteries are fully charged, the adaptor can be disconnected, and the 715 will operate for eight hours before before recharging is required. The batteries can be recharged by leaving the AC adaptor connected overnight.

It will not harm the batteries to leave the adaptor connected to the 715 after they are fully charged.

Probes

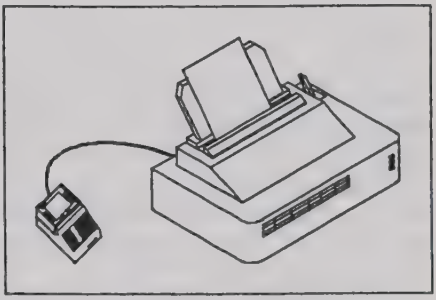


Connect the gage probes to the Gage Amplifier by plugging them into the connectors on the back of the unit. Do not force the connectors; they are keyed by two small indentations on the upper edge of the connector shell, and can only be inserted when correctly aligned.

Up to four gage probes can be connected to the Gage Amplifier at one time.

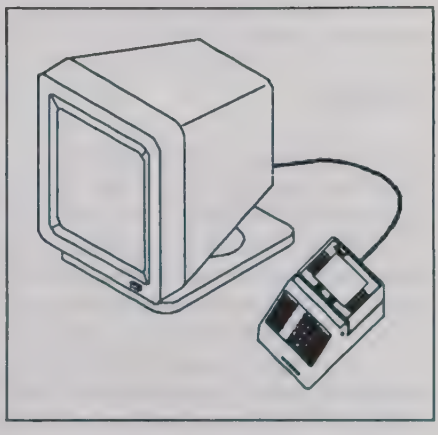
Use only gage probes supplied by the L. S. Starrett company. The collector is exactly matched to the electrical and mechanical characteristics of the Starrett probes; the use of probes from other sources can result in electrical damage and/or inaccurate readings.

Printer



The 715 can be connected to a printer, to record results as testing is performed, or to print out summary reports of previous tests. A serial printer can be connected directly by means of a serial interface cable (Starrett Part # 60643), plugged into the RS232 data port on the back of the 715, as shown. A parallel printer can also be connected to this port, via a serial-to-parallel interface converter (commercially available) and a second, parallel cable. Consult the 715 Reference Manual for a detailed description of the interface and its functionality.

CRT or Computer

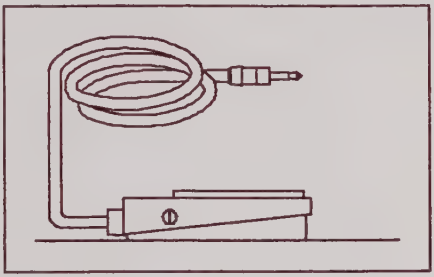


Optionally, the 715 can be connected to a CRT or computer for remote control or display, or for data recording and analysis, by means of an optional interface cable (Starrett Part # 60642), plugged into the RS232 data port on the back of the 715 as shown. Consult the 715 Reference Manual for a detailed description of this interface.

Some computers or CRT displays which use a 25 pin serial communications connector will require a special adapter (Starrett Part # ?????) to connect to this interface cable. Consult the hardware and software reference manuals for the device in question to determine the precise requirements for such a connection.

Foot Switch

For hands-free printing or storing of data, a foot switch (Starrett Part # 720-3) may be plugged into the back of the 715 as shown. The data collector can be programmed either store or print out the data when this switch is pressed, allowing the operator to have both hands free for the test procedure. To select the action initiated when the switch is pressed (PRINTING, STORING, or both PRINTING & STORING), see the SETUP section of this manual.

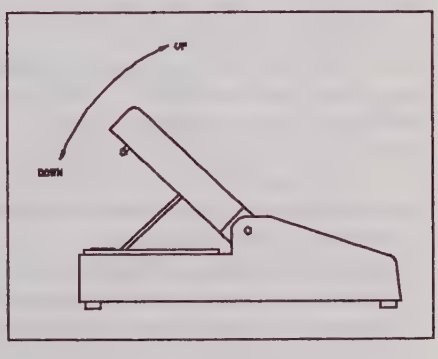


GET SET!

Screen Position

The viewing screen pivots on a hinge just below the MORE and PREV keys, and can be raised into a comfortable viewing angle by swinging up its back edge. When not raised, the screen is held to the case by a spring tab on its back; when raising the screen, the latching force of this tab must first be overcome before it will move.

A pivoting wire bail on the back of the screen swings down to support it. This bail can be set in any of several grooves in the case to retain the screen in the desired position.



Applying Power

If line power is available at the test location, the 715 can be left plugged in while in use. If line power is not available, it can be plugged in elsewhere overnight, and will then operate on its batteries for approximately 8 hours before recharging is necessary.

Turn the unit on by toggling up the power switch on the back of the unit. The 715 will first display a starting screen, identifiable by its depiction of the Starrett trademark, for approximately three seconds, and then execute its startup routine.

Warm vs Cold Start

This startup routine will sense the state of the Gage Amplifier memory, and perform either a "warm" start or a "cold" start.

If the batteries are not fully discharged, all part and characteristic descriptions and data will still be in the memory, and the unit can resume operation as if it had never been turned off. In this case, the unit executes a "warm" start, and immediately enters RUN mode, displaying a single curved meter screen for channel 1.

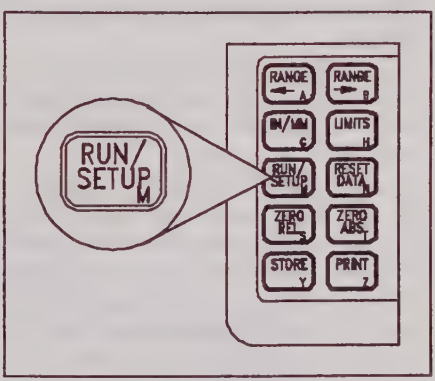
If the batteries are fully discharged, all descriptions and data in the memory have been lost, and the unit will have to be completely initialized before use. In this case, the unit executes a "cold" start. First, the memory is completely cleared, and a message reporting this is displayed on the startup screen below the Starrett trademark. Next, the unit is loaded with a default part set of three generic parts, two with a single characteristic each, and one with two, and a message to this effect displayed on the screen adjacent to the first one. Next, all calibration and zero constants are set to default values. Next, the A-to-D converter used to convert probe outputs to digital data suitable for displaying and storing is calibrated. This calibration operation takes about two seconds, and its progress is displayed on a screen which replaces the screen showing the Starrett trademark. Finally, the unit enters the RUN mode, displaying a single curved meter screen for channel 1.

It is possible to "force" a cold start, even if the memory contents are still valid. To do this, turn the unit off, and then back on, while holding down any of the keyboard keys. The unit will sense the keyboard state, and execute a cold start exactly as if the memory data had been completely lost. **WARNING:** Do not force a cold start if any part and characteristic descriptions or data in the memory have not been saved to a memory card; a cold start completely clears the unit memory, discarding any data which it might contain.

Operating Modes

The 715 has two basic operating modes: **RUN** mode, when it is displaying gage probe readings, and **SETUP** mode, when menu screens are being used to configure the system for a particular test, or change operating parameters.

Mode Selection



When first turned on, the Gage Amplifier will be in **RUN** mode. It can be switched to **SETUP** mode, for access to the menu structure, by pressing the RUN/SETUP key; this key causes the Amplifier to toggle back and forth between **RUN** mode and **SETUP** mode, switching from whichever of the two it is currently in to the other, whenever it is pressed.

It is possible to switch to **RUN** mode from **SETUP** mode while any of the **SETUP** mode menus is active. When switching from **RUN** mode to **SETUP** mode, the system will always return to whichever menu was active the last time it was in **SETUP** mode

RUN Mode

In **RUN** mode the 715 is displaying the data from one or more gage inputs. Data from a single gage input is displayed full screen; data from multiple gage inputs is displayed split screen, with either 2 channels (always channels 1 & 2) or all 4 channels displayed at a time. When the data from multiple inputs is displayed, one is designated by the system user as the "active" channel; when the data from a single input is being displayed, it is, by default, the "active" channel.

When in **RUN** mode, operation is controlled from the other 9 yellow-lettered keys on the left hand side of the main keyboard, plus the GAGE and " – " keys, and the keys for the numerals 1 through 4. Only the currently active channel is affected by these keys.

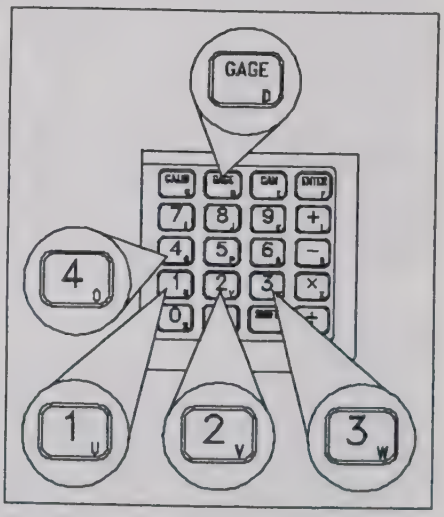
Channel Selection

The operator controls which channel is "active", and currently being displayed as follows:

When displaying the data from a single input, pressing the GAGE key will cause the system to select another input channel to display. The system cycles through the four input channels in round-robin fashion, advancing one channel for each time the GAGE key is pressed.

When displaying the data from two channels (always channels 1 & 2), or from all four channels, the active channel is indicated by a "pointing-finger" graphic symbol on the screen. To change the active channel, press the numeric key, 1, 2, 3, or 4, corresponding to the desired channel, on the keypad.

When displaying data from a single channel, the numeric keys will have no effect; when displaying data from multiple channels, the GAGE key will have no effect.



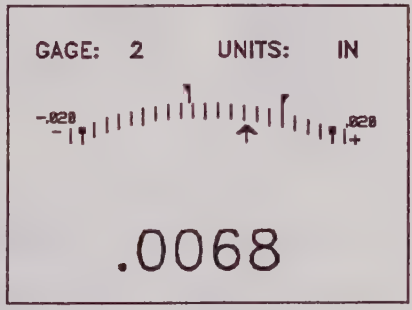
Display Formats

The data from gage input(s) is displayed on the the screen both graphically and numerically.

The graphic display shows the gage reading as it would appear if the gage were connected directly to a meter. A zero-center meter scale is displayed, with an arrow (representing the meter "needle") pointing to the data value. Figures displayed at either end of the scale indicate the full-scale range of the display, and a pair of small tick marks adjacent to it mark the present values of the limits for the channel being displayed. As the gage data changes, the "needle" moves to the point corresponding to the new value.

The numerical display is a signed decimal number representing the gage output value, shown on the screen immediately below the meter face. This number can be set by the user to have from 1 to 6 significant digits; see **MENUS - PARAMETER SET** in the Reference Manual for details.

The meter screen displayed when the Gage Amplifier is first turned on is a single-channel display with a curved meter, with channel 1 selected, and the meter range & units set to ±.001 inches.



Any of the gage amplifier outputs can be displayed with this meter screen; selection of which channel is displayed is made with the GAGE key. See **RUN Mode - Channel Selection**, above, for details.

The full-scale range of the meter can be set to match the data range by means of the two keys RANGE← and RANGE→. Similarly, the units displayed, inches or mm, can be selected as desired by means of the IN/MM key. See **RUN Mode Controls - Units** and **RUN Mode Controls - Range** for details.

Other Displays

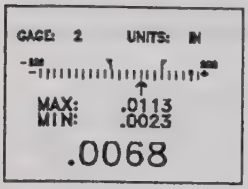
Nine other meter screens are available, to suit the particular requirements of specific measurements setups, or the preference of the user.

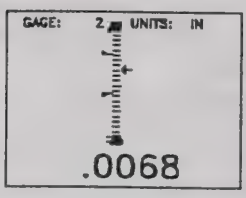
The meter scale can be displayed as a flat horizontal meter, or as a vertical meter, if desired. the data from channels 1 and 2 can be displayed simultaneously, on a split screen, or the data from all four channels, on a screen divided in four.

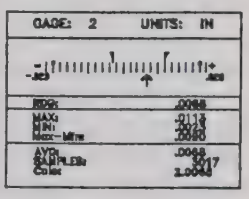
In most of these meter screens, the words OVER or UNDER (or OV or UN), as appropriate, will be displayed if the measured value is outside of the limits currently defined for the channel being displayed. Also, in some of them, additional information about the channel, such as the min or max values observed, the data spread, or the average value, will be shown as well.

These nine additional meter screens are shown below. For further details on their particular features, see **OPERATING MODES - Display Formats** in the Reference Manual

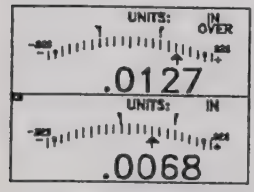
Other Single-Channel Displays:

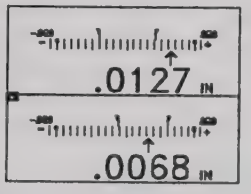


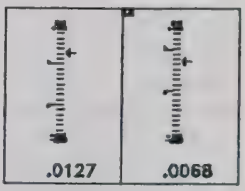




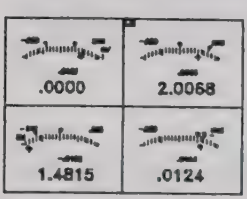
Dual-Channel Displays:

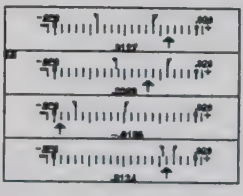


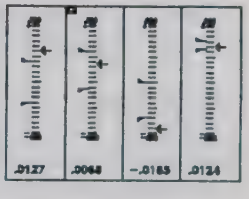




Quad-Channel Displays:





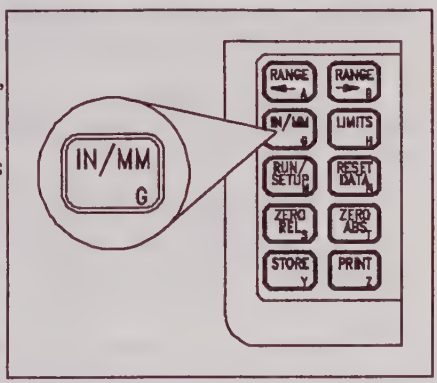


RUN Mode Controls

Units

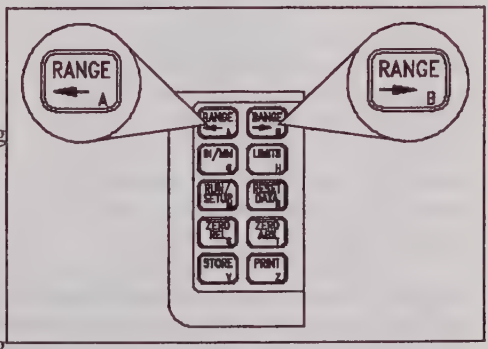
The data from the gage inputs is displayed in either English (inches) or metric (mm) units. Pressing the IN/MM key causes the system to toggle between the two types. Both the numeric and the graphic displays are changed, and all four channels, including those not being currently displayed, are affected.

When switching between the two types of units, the full scale limits of the meter will be modified by a factor of 10 to compensate, more or less, for the difference in magnitude of the two units, inches and millimeters. Thus a display in which the meter range was ±.001 inches would switch to a display with a meter range of ±.010 mm, and one with a meter range of ±2.000 mm inches would change to one with a meter range of ±.200 inches, etc.



Range

The full-scale meter range of each channel can be any one of eight values from ±.0001 inches to ±.200 inches, if displaying English units, or from ±.0010 mm to ±2.000 mm, if displaying metric units. The displayed range for each channel can be selected explicitly by the user, or the unit can be programmed to select the range automatically.



If user-selected, meter range is set on a channel by channel basis, using the two keys, RANGE← and RANGE→, on the left hand side of the main keyboard. Pressing RANGE← lowers the range (±.200 ⇒ ±.100 ⇒ ±.020 ⇒ ±.010 ⇒ ...) of the active channel; pressing RANGE→ raises it (±.0001 ⇒ ±.0002 ⇒ ±.001 ⇒ ±.002 ⇒ ...).

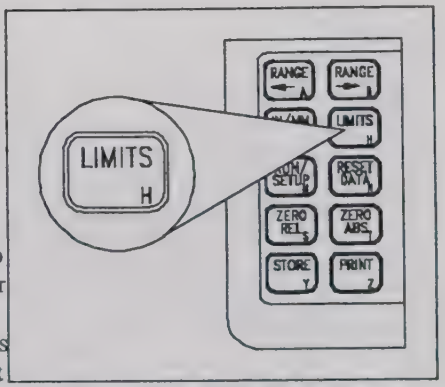
If automatically selected, meter range is set on a channel by channel basis by the 715, the range for each channel being selected so as to display the gage data for that channel as close to full scale as possible. As the data changes, the 715 will track it and change the meter range to a higher or lower value as appropriate without operator intervention.

The type of ranging in effect is controlled by the parameter AUTO RANGING in the DISPLAY FORMAT menu; see **MENUS - DISPLAY FORMAT** in the Reference Manual for details.

Whichever ranging mode is in effect applies to all four channels uniformly; it is not possible to have auto-ranging in effect on some channels while user range selection is in effect on the others.

Range selection affects only the format of the displayed meter face, and has no effect on the precision of the numeric display; the displayed precision is controlled by the parameter DISPLAY DIGITS in the PARAMETER SET menu; see **MENUS - PARAMETER SET** in the Reference Manual for details.

Limits



A High and a Low limit value exist for each channel, and each can be set to any desired value. Pressing the LIMITS key causes the screen to display the limit settings for the currently active channel; to display the limit settings for some other channel, press the numeral key corresponding to the desired channel after pressing LIMITS. A limit is selected for changing by pressing one of two function keys to the left of the screen, F1 for the upper limit, F2 for the lower.

A line of UNDERSCORE characters (_ _ _ _ _) will be shown on the display at the location where the limit data is to be entered. The length of this line indicates the maximum number of characters which can be entered, and a cursor (a blinking UNDERSCORE just below the line) indicates where the next character entered will be placed. The new value for the limit is then typed in, using the keys for the ten numeric digits and the '-' and '.' keys, with the sign (if negative) being entered first.

If an incorrect character is accidentally entered, it can be erased by pressing the CAN (CANcel) key. Pressing CAN when the cursor is at the first position cancels the data entry operation, returning the data to its original value.

When the data has been correctly entered, pressing the ENTER key will cause it to be accepted and stored in memory. Pressing ENTER when the cursor is at the first position enters a value of ZERO for the data.

When limit setting is complete for all desired channels, press PREV. This will cause you return to the measurement screen for the channel which was being displayed prior to pressing LIMITS.

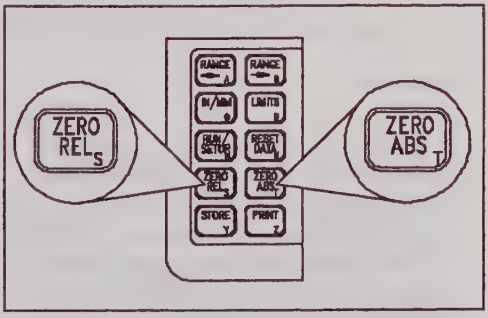
Limits are indicated in the data display by pointers adjacent to the meter scale, on the opposite side from the "needle".

Setting Zero

There are two methods of setting zero , relative and absolute.

Absolute Zero Setting

The probes used by the 715 are most accurate when operated close to their balance point, at which point their output voltage is zero. Pressing ZERO ABS causes the 715 to interpret a zero voltage as an indication of zero displacement, and thus display zero at the balance point.

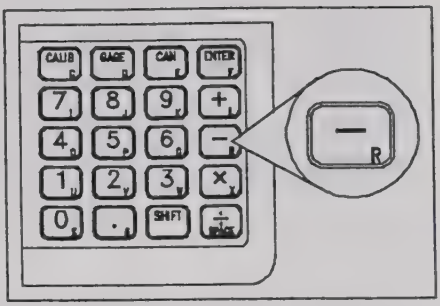


Relative Zero Setting

ZERO REL forces the 715 to sense and remember the current probe output voltage as the voltage to be interpreted as zero, no matter whether the probe is balanced or not. Pressing ZERO REL identifies the current probe position as the zero point, and forces all future measurements to be expressed as offsets relative to that position.

This capability is useful when checking a part against a master. With the probe on the master, press ZERO REL. Then replace the master under the probe with the part to be checked. The resulting indication will be the physical difference in size between that part and the master.

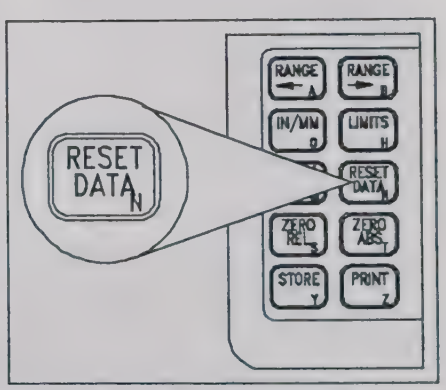
Data Polarity



Pressing the "−" key while in **RUN** mode has the effect of reversing the polarity of the gage reading for the active channel. If the gage reading, for example, is +.01002, then pressing "−" will cause it to change to -.01002. Pressing the key again will have the effect of reversing the polarity again, back to the original value. Both the needle position and the numeric display are affected.

The polarity of the "meter" itself, and of the limits, is not affected by this key; only the data polarity is changed.

Reset Data

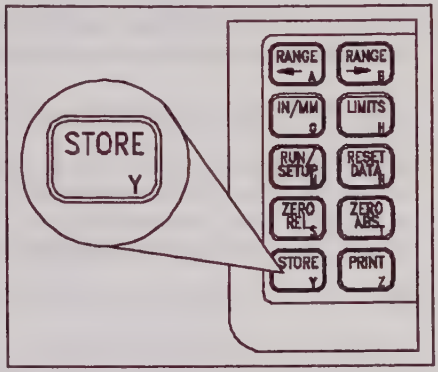


While in **RUN** mode, the input data on all four channels is regularly sampled, and certain attributes computed for each channel. These sampled attributes are MIN (the lowest data value for a channel since the start of sampling), MAX (the highest data value for a channel since the start of sampling), TIR (MAX minus MIN), AVG (the average data value for a channel since the start of sampling), and SAMPLES (the number of times that data on the four channels has been sampled since the start of sampling). Some or all of these attributes are displayed in some of the meter screens, and all are available for use in PRINT LIST and MATH functions.

In order for these computed values to be useful, it is necessary to periodically initialize them and restart sampling. This is accomplished by pressing the RESET DATA key while in RUN mode; this causes MIN, MAX, and AVG for each channel to be set to the current data value for that channel, and SAMPLES to be set to zero.

Storing Readings

Pressing the STORE key while in RUN mode causes the Gage Amplifier to store the values of the characteristics for the currently selected part, for later retrieval or printout. The value stored for each characteristic is whatever channel and function is defined for it on its Characteristic Entry menu. See**Operating Modes - Storing Readings** in the Reference Manual for details on how to specify the channel and function of a characteristic.

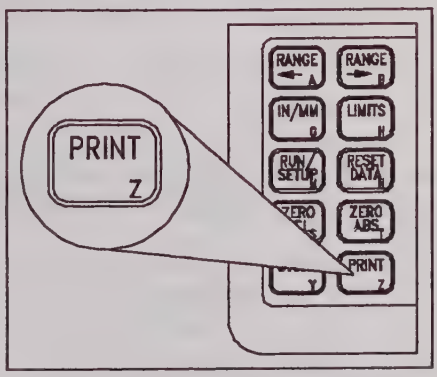


Printing

Pressing the PRINT key while in RUN mode causes test data to be sent from the serial data port to the printer or terminal or computer connected thereto.

The type and format of the data sent is controlled by a program stored in the Gage Amplifier. Access to this program is via the PRINT LIST menu. See **MENUS - PRINT L(i)ST SELECTION** in the Reference Manual for details.

When the Gage Amplifier is first turned on, a default Print List program is loaded for each part, which will cause the characteristics for that part to be transmitted in sequence, separated by commas, ending with a carriage return & line feed.

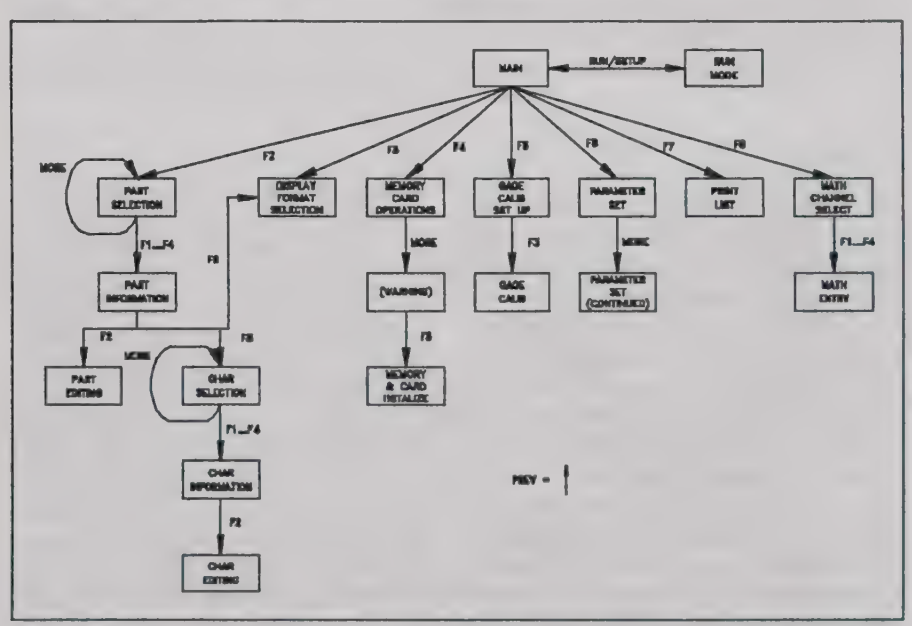


SETUP Mode

SETUP is the 715 operating mode in which system parameters are changed, and in which non-display system operations are initiated.

Menu Structure and Operation

In **SETUP** mode, any function to be changed or operation to be initiated is chosen by making selections from a menu. A number of menus, divided into seven functional sets are provided. Some sets consist of only a single menu; others have a whole series of menus, each concerned with a particular subfunction.



A single master menu, MAIN is the control center from which a menu set is called, and to which the system returns before calling the another. MAIN itself performs no direct system operations; its sole purpose is to call whichever set of the special-function menus is required.

It is not possible to move directly from one menu set to another. The user must first return to the MAIN menu from one set before entering another.

For further information on the menu structure, and about the functionality of individual menus, see **MENUS** in the Reference Manual.

Selecting Options and Menus, and Initiating Actions

The menus are used by pressing the function keys (F1 through F8) on both sides of the screen, and the MORE and PREV(ious) keys below it.

F1 through F8: The different ways in which the function keys operate are as follows:

- An operation is initiated by pressing the function key next to its name
- A menu for further action is selected by pressing the function key next to the menu name
- A channel #, math operator, printing separator, etc. is selected by repeatedly pressing the function key next to the class name, cycling through the possible choices until the one desired is displayed.
- A data item is selected for entry by pressing the function key next to its name.

MORE: This key is used when a menu or list is larger than can be displayed on a single screen. In such a case, pressing MORE causes an extension menu/list to be displayed, listing the menu or data items which could not be shown on the original screen.

When a menu or list is capable of being extended by pressing MORE, that key will be highlighted by a black rectangle displayed immediately above it on the lower edge of the screen

PREV(ious): This key is used to return to the menu displayed previous to the current menu. Pressing PREV repeatedly will return the system to displaying the MAIN menu.

Keyboard Data Entry

Whenever the 715 expects data entry from the keyboard, a line of UNDERSCORE characters (_ _ _ _ _) will be shown on the display at the location where the data is to be entered. The length of this line indicates the maximum number of characters which can be entered, and a cursor, a blinking UNDERSCORE just below the line indicates where the next character entered will be placed. The ten numeric digits (0 ... 9), the decimal point (.), and the symbols for the four arithmetic operations (+, −, ×, and ÷) can be entered directly. The 26 alphabetic characters (A ... Z), the percent sign (%), the pound sign (#), and the space ( ) are entered by holding down the SHIFT key while pressing the appropriate key as indicated by the legend at that key's lower right hand corner.

If an incorrect character is accidentally entered, it can be erased by pressing the CAN (CANcel) key. Pressing CAN when the cursor is at the first position cancels the data entry operation, returning the data to its original value.

When the data has been correctly entered, pressing the ENTER key will cause it to be accepted and stored in memory. Pressing ENTER when the cursor is at the first position enters a value of ZERO for the data.

GO!

Load Part and Characteristic Parameters

Load the descriptions of the parts to be tested and the particular measurements to be made on them into the Gage Amplifier. A description of what this information consists of, and how it is organized, can be found in the section, **GAGE AMPLIFIER DATA BASE**, in the Reference Manual

The data base loaded can be either the system default data base, or a data base specifically created for particular tests to be performed.

Default Data Base

The default data base provided with the Gage Amplifier contains three parts, two with a single characteristic and one with two, and is suitable for taking measurements with a single probe and printing them out. For details, see **Appendix B - Default Data Base**, in the Reference Manual. This data base is loaded as follows:

- From the MAIN menu, press F4 (MEMORY TRANSFER), then MORE, and finally F3, to access the MEMORY INITIALIZATION menu.
- Press F2 (INITIALIZE MEMORY).
- After receiving the message "Memory Cleared, Defaults Loaded", press PREV three times to return to the main menu

This procedure will delete whatever data base was previously and load the default data base in its place.

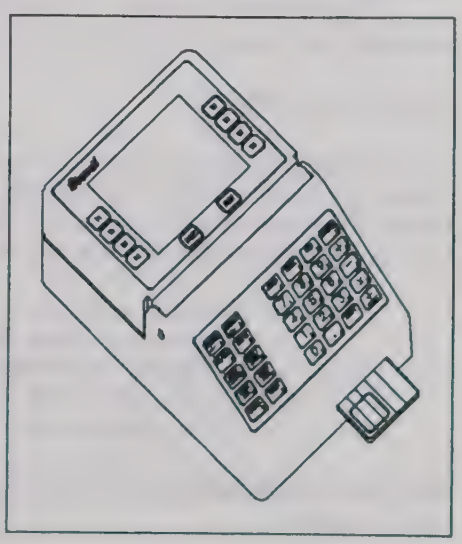
New Data Base

The default data base is fairly simple and straightforward. If it is desired to utilize more of the capabilities of the Gage Amplifier, such as using more than two probes, or erforming data reduction on the readings, or providing more elaborate formatting on the output data, it will be necessary to either modify and expand the default data base or replace it with a new one.

This expansion/modification can be done in any of three ways:

- Modifications to the existing data base, or a complete new one, can be keyed in by hand, using the keys on the upper and lower sections of the amplifier keyboard

- Modifications to the existing data base, or a complete new one, can be entered remotely, by means of keystroke sequences transmitted to the amplifier via the serial port on the back of the unit. Such sequences could be generated by typing on the keyboard of a terminal connected to the serial port, or they could be generated by data preparation software running on a computer connected to the port. See **INTERFACES** in the Reference Manual for the details on how to connect a terminal or computer to the port, and how to perform this programming/data entry



- A complete new data base, previously created, can be loaded from a data memory card. Once a data base has been created, it can be saved on a data memory card (Starrett Part # 60640), for subsequent reloading into the system. In this way, the necessary

setups for a number of tests on several different parts can be saved in a data memory card library, and the data base for whichever test is to be performed can be loaded as part of the preparation for that test.

To load a saved data base, insert the data memory card, arrow side up, into the slot in the front surface of the collector, far enough in that you feel it "seat"; then perform the step, LOAD ALL FROM CARD, described in the section, **MENUS - Memory Transfer**, in the Reference Manual. If only the data base for a single part is needed, it can be loaded using the LOAD PART FROM CARD option in the MEMORY TRANSFER menu.

Calibrate and Zero The Probes

Before performing any testing, each probe must be calibrated and zeroed, so that the Gage Amplifier can accurately convert the probe output signal into a measurements.

To calibrate a probe, its output is measured at two positions a known distance apart; the Gage Amplifier then uses the difference in probe output at the two positions, and the physical distance between them, to calculate a scale factor which will convert the probe output into a position figure.

To zero a probe, it is placed in the physical position selected to be the "zero" point, and the unit is notified; from then on, the Amplifier will interpret that probe output as a zero reference, and base all measurements relative to that point.

Four pairs of calibration scale factors and zero reference values are maintained by the Gage Amplifier, one pair for each probe. Each pair is associated with a particular probe input, and is used by the unit to interpret readings from that input. These factors are stored in the unit memory, and are retained, even if the unit is turned off, as long as battery charge remains.

Each probe must be calibrated and zeroed whenever turning the unit on after the batteries have run down. Whenever installing a new probe, it must be calibrated and zeroed before use. Additionally, all probes should be calibrated and zeroed on a regular basis to ensure system accuracy.

Calibration Procedure

The calibration procedure, which must be repeated for each active gage probe, is as shown on the following page.

Starting from the MAIN menu:

1 Press F5 (CALIBRATE PROBES), to display the GAGE CALIBRATION menu.
2 Press F1 (GAGE #). You will be prompted to enter the number of the gage you wish to calibrate; key in the number (1, 2, 3, or 4), and press ENTER to store it.
3 Press F2 (CAL STD). You will be prompted to enter the difference in size between the two standards used to calibrate this probe; key in the number (in inches, if IN display is selected; in mm if MM display is selected), and press ENTER to store it
4 Press F3 (BEGIN CALIBRATION). The unit will then display a Calibration Procedure window
5 Place the first standard in the test fixture, in the position sensed by the gage probe being calibrated. Press ZERO REL.
6 Place the second standard in the test fixture, in the position sensed by the gage probe. Press CALIB.
7 The screen will display the message: CALIBRATION COMPLETE. Press PREV; this will return you to the MAIN menu.

Repeat this procedure (steps 1 through 7) for each of the active probes

This procedure assumes that the probes are installed in a test fixture into which gage blocks or other calibration standards can be inserted in place of the parts to be tested, and that two standards, the first whose size represents the zero point and the other differing from it by a known fixed amount , are available for each probe.

More information regarding calibration and zeroing can be found in the section, **MENUS - CALIBRATE PROBES**, in the Reference Manual.

The probes can also be zeroed during operation by the use of the ZERO REL and ZERO ABS keys, as described in the section, **GET SET! – Setting Zero**, above.

TC Offset

For maximum accuracy, the Model 715 Gage Amplifier requires that a parameter, specific to each unit, be stored in its memory. This number, which has a range of ±0.999, is used by the unit temperature compensation logic to achieve full rated accuracy over the full operating temperature range

The proper value for this parameter, the TC OFFSET, is determined at the factory for each unit, and placed in its memory prior to shipment. The system batteries, when fully charged, are capable of supporting the memory for more than two months when the unit is turned off, so this stored parameter will never be lost under normal circumstances.

If the batteries are accidentally allowed to fully discharge, requiring a complete "cold" restart, it will be necessary to reload this parameter into the unit memory. It will also be necesary to reload this parameter if a LOAD ALL FROM CARD operation has been performed, using a memory data card which was written using a STORE ALL TO CARD on a different unit.

The procedure for reloading the TC OFFSET parameter into the unit are as follows:

1 In **SETUP** mode, starting from the MAIN menu, press F5 to go to the GAGE CALIBRATION menu, where the current value for this parameter is displayed.

2 Press F4 (TC OFFSET) - you will be prompted by a line of underscores to enter the parameter.

3 The correct parameter for each unit is printed on a label located on the bottom of the case, thus: **TCO = ±0.nnn**

4 Enter this number exactly as printed on the label, using the keys for the numeric digits, the decimal point, and the minus sign. Then press ENTER.

5 Press PREV to return to the MAIN menu.

Select a Part to Test

After the part description, together with its characteristics and their descriptions, has been loaded, identify that part to the Gage Amplifier as the part to be tested by selecting it.

From the MAIN menu, press F2 (SELECT PART), to access the PART SELECTION menu. Select the part you wish to test, by pressing the function key next to its number/name (if more than three parts are in the data base, you may have to

press MORE one or more times to display them all). Now press PREV as many times as necessary to return to the MAIN menu. The part selected will now be identified by number in the upper left hand box of that menu.

Final Preparations

Two final steps are necessary before beginning to test: data left over from previous testing must be deleted, and the test fixture and gages should be checked one time with a known standard part.

Delete Old Data

Before testing and recording measurements on parts from one lot, it is necessary to delete from the Gage Amplifier memory any old data left over from previous lots. If this is not done, any new measurements you record will be combined with that already there, making it hard to identify which were the old readings and which the new, and obscuring tracability.

To delete the old measurement data for a part, first the part must be selected, via the PART SELECTION menu; then the CHARACTERISTIC SELECTION menu for that part must be accessed and the data for each characteristic be deleted, one characteristic at a time. See **MENUS - CHARACTERISTIC OPERATIONS** in the Reference Manual for details on how to do this.

Gage a Standard Part

It is a good policy to have the first part tested be a standard part, nominal in all dimensions, or, failing that, a part with all dimensions known. This is a good final check that the units, range, polarity, calibration, and zeroing of all gage probes are all correct, and that the test fixture is locating the part and the probes correctly.

Place the standard part in the test fixture, and (if necessary) close it so that the probes are in position and gaging the part. With the Gage Amplifier in **RUN** mode, look at the indicated dimension shown for each active channel, and check the readings against the expected values.

If the readings for all gages are as expected, remove the standard part from the test fixture and return it to its proper storage place, and proceed to make measurements on production parts as described below. If not, check to ensure that all preliminary steps have been correctly carried out. Has the unit been properly calibrated

and zeroed with the gage probes and test fixture being used? Has the proper Gage Amplifier data base for the part being tested been loaded, and the proper part selected?

Take and Record Measurements

With the test fixture and its probes connected, the probes calibrated, and the part data base loaded, the system is now ready to make measurements.

Place the first part to be measured in the test fixture and (if necessary) close it so that the probes are in position. With the Gage Amplifier in RUN mode, display the output of each probe by cycling through the active channels, and record the "meter" indications..

The Gage Amplifier allows you to record the test data directly, without cycling through the probe output displays, in either of two ways. You can store it in the unit memory, by pressing the STORE key while the part is in the test fixture, or you can transmit it to whatever device is connected to the unit serial data port by pressing the PRINT key. Both of these recording methods are discussed below. If you choose to use only the basic display capability of the Gage Amplifier, and neither STORE nor PRINT, you can, of course, record the measurement results in the conventional way, with a paper & pencil.

Repeat this procedure for each part in the lot.

Storing Measurement Data

When you press the STORE key, the Gage Amplifier stores the current value of each characteristic of the part in its memory.

Each value is stored with 6 digits of precision, irrespective of the number of digits currently specified for meter screen display, and is tagged as to which characteristic it represents, and the time and date at which the reading was recorded.

If the test fixture or procedure is one which makes pressing the STORE key difficult or awkward, it may be desireable to install a foot switch, as described above in **GET READY - Setting Up**, so as to leave both hands free. Such a switch can be programmed to cause the Amplifier to STORE, or PRINT, or both STORE and

PRINT, as desired; see **MENUS - PARAMETER SET** in the Reference Manual for instructions on how to select the foot switch action.

Printing Measurement Data

In addition to storing the results of a test internally in the Gage Amplifier, it is also possible to "print" it out; that is, to transmit the data to a printer over a cable connected to the Gage Amplifier serial interface. The device on the other end of the cable does not have to be a printer. It could be a CRT terminal, in which case the data would be displayed on the CRT screen, but no permanent record would be made. It could be a computer, in which case the transmitted data would be subjected to more or less processing and stored in the computer memory for use later. For information about any of these configurations, see the section **INTERFACES - Serial Interface** in the Reference Manual.

The most likely device to be connected to the serial port is the aforesaid printer. Hence the operation of transmitting data out via the serial port is called "printing" irrespective of which type of device, printer, terminal, or computer, is actually at the other end of the cable.

Two types of printing operations are possible. It can be done while measuring parts, on a part by part or second by second basis, each transfer outputting data on the part currently being tested. Alternatively, it can be done as a summarizing operation, subsequent to a series of tests, outputting the characteristic data for a whole lot of tested parts.

Printing While Making Measurements

Printing while making measurements can initiated in two ways: it can be triggered on an instance by instance basis, by pressing the PRINT key or the foot switch (if the foot switch is programmed to cause a print operation to occur) , or it can be made to occur continuously, as often as the gage inputs are sampled and the statistical data functions computed.

When a print operation takes place, what data is sent out (which functions of which channels) and how it is formatted (what separators are inserted between data fields, and how many lines the output is printed on) is controlled by a print control program (called the print list) which is part of the data base for each part. The data

sent out can be as simple as just the measured value for one or more channels, or can be a complex function of the values, statistical functions, and the status of two or more channels, and can include the time, date, and channel number. See **MENUS - PRINT LIST SELECTION**, in the Reference Manual for details on how the print list operates and how print lists are programmed

For the default part set, only one of the three parts, part number 10, is programmed to output data when printing is triggered. For that part, the data sent out is the measured value for channel 1, followed by a carriage return. For the other two, parts 20 and 30, the print lists are empty, and no data is sent out.

Triggered Printing

When the PRINT key (or the foot switch, if it enabled to cause printing) is pressed, data is sent to whatever device is connected to the serial interface. The transmitted data and format are controlled by the print list of the currently selected channel. One transmission is initiated each time the key (or switch) is pressed. A typical triggered print output would be as shown here:

```
03/22/93 09:56,  .004877,  .010940, -.001976
```

Triggered printing is the mode of operation which would be used while making measurements on a lot of parts, one after another, where it is desired to display and/or capture the data for each part in turn while it is in the test fixture.
Triggered printing is only operative in **RUN** mode; during **SETUP** mode it is disabled, and the only way to print data is either as part of a a part data report or by means of a characteristic data list.

Continuous Print

While in **RUN** mode, the Gage Amplifier is operating in a loop, sampling each active gage input in rotation, updating its statistical functions (Min, Max, Avg, and TIR), and computing the math function for each channels. When continuous printing is enabled, at the end of each iteration of this loop, data is sent to whatever device is connected to the serial interface, in the format determined by the print list for the currently selected part. Depending on how many channels are active, and how complex the math

functions to be computed are, the loop iteration rate, which controls the sampling and print rate, could be anywhere from 2 to 10 times per second. The print output while in continuous print mode would be as shown here

```
  :          :          :          :
  :          :          :          :
10:20,  .005312,  .018870, -.001432
10:20,  .005406,  .018804, -.000567
10:20,  .005380,  .020563,  .002003
10:21,  .005367,  .019408. -.000381
  :          :          :          :
  :          :          :          :
                                . . . etc.
```

Continuous printing is only operative in **RUN** mode; during **SETUP** mode it is disabled, and the only way to print data is either as part of a a part data report or by means of a characteristic data list.

As a mode, continuous printing is enabled/disabled from the PARAMETER SELECT menu. See **MENUS - PARAMETER SET**, in the Reference Manual for details.

Continuous printing is the the mode of operation which would be used while making measurements on a single part. It would be used, for example, where it is necessary measure some dimension repeatedly while making adjustments, until a particular value for that measurement is arrived at, or where the operator must vary the axis of measurement slightly, so as to ensure that a maximum or minimum value is found.

Continuous printing is disabled for all three parts in the default part set.

Printing Out Stored Data

Stored data from earlier tests can be printed out in two different ways. It can be printed as part of a Part Data Report, along with the part and characteristic data, or it can be printed separately, as part of an Output Characteristic operation.

Part Data Reports

A Part Data Report is a complete report on one specific part in the Gage Amplifier data base. It includes the complete description of the part, descriptions of each of its characteristics, and all currently stored data for each of its characteristics. The part reported on is the currently selected part; data for characteristics of other parts is not reported.

A Part Data Report has a specific format; transmitting the part description first, then the description of and data for the first characteristic, then the description of and data for the second characteristic, etc. For an exact description of a part data report, see **MENUS - Part Information** in the Reference Manual.

To print a Part Data Report, first select the part to be reported on as described in **Select a Part to Test**, above, but do not press PREV twice to return to the MAIN menu. Instead, press F4 (PART DATA REPORT); this will cause the report to be printed. After printing is complete, press PREV twice to return to the MAIN menu.

Output Characteristic

It is also possible to print out just the data for one characteristic of one part. Such a report is called a characteristic report, and consists of only the stored characteristic data, plus enough information to identify the date and time the measurements were made, and which subgroup of parts were being measured.

The characteristic/part whose data is printed out is the currently selected characteristic of the currently selected part. All curently stored data for that characteristic is printed; no data is printed for any other parts or any other characteristics.

The Gage Amplifier can print out a characteristic report in either of two formats, column format, or CSV (Comma-Separated Value) format.

To print a Characteristic Report, first select the part to be reported on as described in **Select a Part to Test**, above, but do not press PREV twice to return to the MAIN menu. Instead, press F3 (CHARACTERISTICS), to access the CHARACTERISTIC SELECTION menu. Select the characteristic whose data you wish to print out by pressing the function key next to its number/name (if more than three characteristics are defined for the part, you may have to press MORE one or more times to display them all). This causes a CHARACTERISTIC EDITING menu for that charac-

teristic to be displayed. Now press either F3 (OUTPUT COL. FMT) or F4 (OUTPUT CSV FMT); this will cause the desired report to be printed. After printing is complete, press PREV as often as necessary times to return to the MAIN menu.

Column Format

In column format, the data is printed out one reading per line, at maximum precision (6 digits), with each line being terminated by a carriage return. Each line begins with a number indicating whether the reading is the first reading in a subgroup (30 = first; 10 = not first), then the date and time at which the reading was made, and then the data. All elements on each line are separated by spaces.

A sample of a Characteristic Report in column format is shown below.

```
30  05/18/93  09:43   .001899
10  05/18/93  09:46   .002178
10  05/18/93  09:48  -.001045
10  05/18/93  09:51   .001104
30  05/18/93  10:11   .006541
10  05/18/93  10:14   .004810
 :      :        :        :
 :      :        :        :
```

CSV Format

In CSV format, the data is printed out with all readings from a subgroup on a single line, at maximum precision (6 digits), separated by commas, with each line being terminated by a carriage return character. Each line begins with a header consisting of: the date on which the first reading in the subgroup was made, and the time of day at which the first reading of the subgroup was made. The header is separated from the data by either another comma, or by two semicolons.

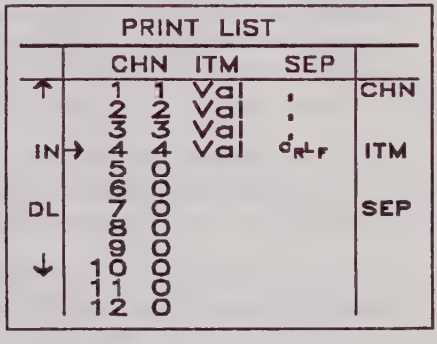
A sample of Characteristic Report in CSV format is shown below:

```
05/18/93 09:43,  .001899,  .002178, -.001045,  .001104
05/18/93 09:51,  .006541,  .004810, ...
```

Programming Display List Formats

While printing during RUN mode, either triggered or continuous, the format of the output data is controlled by a set of instructions stored in the Gage Amplifier called a print list. This print list, created by the user and displayed on the PRINT LIST menu, identifies the data items to be sent out, the order in which they are to be sent, and the separator characters or format codes to be sent with them. Each time a print operation is triggered, the print list program is executed once.

The PRINT LIST menu appears as shown here. Each numbered line on the screen represents one program instruction, specifying a data item to be sent out, and a separator or format item to be sent out after it. The first instruction to be performed is step number 1, at the top, the next, step number 2, immediately below that, and then the next , and so on. The last instruction in the program is identified by having no separator or format item specified. A print list can have up to 24 instructions (two screens worth).



Two examples will illustrate the use and capabilities of the print list. The first is the list on the facing page, the same list as that shown in the picture of the menu screen above:

	CHN	ITM	SEP
1	1	Val	,
2	2	Val	,
3	3	Val	,
4	4	Val	□□
5	X	XXX	(blank)
6	X	XXX	XX

(**X** = Don't Care)

This program will cause the measured values for the four probes to be printed on a single line, channel 1 first, then channel 2, etc., separated by commas, with a return/newline at the end, thus:

```
.002458,  .018009, -.006565, -.020034
```

A second example illustrates the use of statistical sampling functions of the channel data, such as the maximum or average of the sampled values from a channel, and such non-data items as the date, time, or channel number, in the printed output:

	CHN	ITM	SEP
1	X	Date	,
2	X	Time	□□
3	1	Chn#	,
4	2	Chn#	□□
5	1	Val	,
6	2	Val	□□
7	1	Avg	,
8	2	Avg	□□
9	X	XXX	(blank)
10	X	XXX	XX

This program presupposes a test with two active channels. It prints the date and time on one line, the channel numbers on a second, the measured values on a third, and the average values on a fourth, last line, thus:

```
07/28/93, 14:11
1, 2
 .012808, -.003432
 .011531,  .002056
```

For detailed information on how to create and edit a print list for a part, see **MENUS - PRINT LIST SELECTION**, in the Reference Manual.

A separate print list is associated with each part in the Gage Amplifier data base, allowing the format of the printed data to be specific to the test being performed.

Programming Math Functions

When taking a measurement and storing the data, the 715 has the ability to perform data reduction calculations on the raw data, and store the results of these calculations as the value of a characteristic, on a channel-by-channel basis. These calculations, called Math Functions, can be used to calculate the root mean square of the four gage inputs, for instance, or to add a fixed offset to a gage input to produce the true overall dimension, etc.

Multiple math functions can be defined by the user, each associated with a particular characteristics of a part. The maximum number of math functions which can be defined is four; if a part has more characteristics than that, only the first four can have associated math functions.

A pair of menus, SELECT CHANNEL and MATH ENTRY are used to identify which characteristic is to have a math function, and to define the function itself.

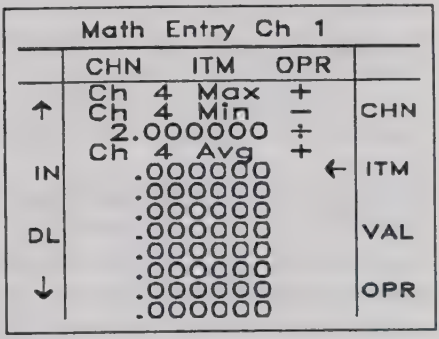
Pressing F8 (MATH ENTRY) on the MAIN menu calls the SELECT CHANNEL menu, which offers a choice of which of the four channel math functions is to be displayed/modified/entered. Since it is not useful to define more math functions than there are characteristics in the current part, if you attempt to do so you will be prompted by a message telling you to define more characteristics.

Once a channel has been selected, a second menu, MATH ENTRY, will be displayed. This menu defines the math function for that channel, displaying list of steps, to be executed sequentially, whose net result is to calculate the desired function. The steps are shown listed vertically in the menu window, with the first step to be performed at the top, the next immediately below that, and then the next , and so on. The maximum number of steps in a formula is 12, the number of steps for which there is room on the MATH ENTRY screen.

Each step specifies an operand, and a operation to be performed, using that operand and an implied accumulator. This accumulator, which is cleared to 0 before the execution of the first step, will contain the final result of the calculation after the

execution of the last one. The formula need not use all twelve steps; a step in which (No Operation) is specified is taken as an "end of formula" marker, and causes the accumulated result created by the previous steps to be stored.

Three examples will illustrate the use and capabilities of the math function. The first is the function below, the same function as shown in the picture of the menu screen above.



Math Entry Ch 1

CHN	ITM	OPR
Ch 4	Max	+
Ch 4	Min	-
2.000000		÷
Ch 4	Avg	+
X X	XX	(blank)
X X	XX	XX

This set of steps will evaluate the function: $((\mathbf{Max_4}-\mathbf{Min_4})\div 2) + \mathbf{Avg}$. using the sampled values for gage input 4. Any characteristics specified to have the (Chnl 1 - Math) as its source would record the results of this calculation as its value.

The second example illustrates the use of a math function to add a fixed offset to a gage input to produce the true overall dimension. Assuming that a 3.164" stack of gage blocks was used to zero gage probe #3 in the test fixture, the math function to achieve this would be:

This set of steps will evaluate the function: $\mathbf{Val_3}+\mathbf{3.164}$, using the current input at gage input 3. In order to use the results of this function, a characteristic would have to specify (Chnl 3 - Math) as its source.

Math Entry Ch 2			
CHN		ITM	OPR
Ch	3	Val	+
	3.164000		+
X	X	XX	(blank)
X	X	XX	XX

It is possible to incorporate parentheses in math functions where a simple sequence of accumulator operations cannot achieve the desired function. A third example, illustrating the use of parentheses, is shown below.

Math Entry Ch n			
CHN		ITM	OPR
Ch	2	Val	+
Ch	2	Avg	–
Ch	4	Min	(
	3.000000		+
	)		×
X	X	XX	(blank)
X	X	XX	XX

This set of steps will evaluate the function: $(Val_2 - Avg_2) \times (Min_4 + 3)$, using the current and sampled inputs for gage input 1 & 4.

For detailed information on how to create and edit a math function for a part, see **MENUS - MATH ENTRY**, in the Reference Manual.

UH OH!

Error Indications

The following events are indications that a system or usage fault has occurred, and that remedial action is required:

Event: The "needle" on the meter screen stays at one extreme end of the "dial" or the other, even when the probe is moved through its entire travel, and recalibration does not correct it

Cause: The connection between the probe and the Gage Amplifier may be defective.

Action: Check to see that the probe has not become unplugged from the back of the amplifier. Reseat all connectors and see if that corrects the problem.

Error Messages

Some error conditions are detected by the system and reported to the user. The following messages are of this type, and indicate that corrective action by the operator is required:

Message: A message reading **MEMORY CLEARED - DEFAULT LOADED*** is displayed when the Gage Amplifier is turned on.

Cause: The Amplifier was disconnected from the AC adaptor for too long a time, and the batteries were fully discharged. Without battery power, the data base and all part/characteristic data has been lost.

Action: Reload the data base, and resume taking measurements. Leave the Amplifier connected to the AC adaptor when not in use.

(*) When the Gage Amplifier is turned on again after battery rundown, it automatically clears the memory and loads a default set of three generic parts. This message is a result of this action.

Message: A message reading CALIB. OUT OF RANGE - REPEAT PROCEDURE is displayed when the CALIB key is pressed in Step 2 of the calibration procedure.

Cause: The sensed difference between the zero point and the calibration point is so small as to indicate tha the probe did not move between the time the ZERO REL key and the CALIB key, indicating that the operator may not have inserted the second physical standard under the probe before pressing CALIB.

Action: Check your calibration procedure to ensure that all steps were performed as specified. Repeat.

Message: A message reading NO CARD IN SLOT is displayed when entering either the MEMORY TRANSFER or MEMORY & CARD INITIALIZATION menu, with the intention of either clearing the card or transferring one or more part definitions to or from the card.

Cause: There is no memory data card plugged into the data card slot in the front if the Gage Amplifier.

Action: Insert a card into the memory card slot, or, if one is already present, make sure that it is properly seated.

Message: A message reading THERE MUST BE ONE CHARACTERISTIC FOR EACH MATH TABLE is displayed when selecting a channel for formula results prior to programming the function.

Cause: Each characteristic can only have one math function as its source item. Hence it is not be possible for more math functions to be required than the number of characteristics of the part. If you select a math function with a higher number than the number of characteristics, the system identifies this as nonuseful, and refuses to continue.

Action: Either return to the MAIN menu and define additional characteristic(s), or check your planned test configuration and data base to determine why you attempted to define a math function which could not be used.

Recharging the Batteries

The 715 Gage Amplifier will operate for approximately eight hours on battery power (somewhat less if the backlight is turned on), or indefinitely if the AC adaptor is left permanently connected. If the unit is inadvertantly left unplugged for more than this eight hour period, all part/characteristic descriptions and data will be lost. If this happens, the initial display when the unit has been turned on will so indicate (see above).

To recharge the batteries and resume use of the unit, it is only necessary to reconnect the AC adaptor, as described in **GET SET! - Applying Power**, above. As soon as the adaptor is reconnected, the unit is ready to reload the data base and resume making measurements. The recharging of the batteries will take place in the background during use.

Once the unit has been connected to the AC adaptor for at least sixteen hours, it is once again capable of operating disconnected for eight hours again. It will not harm the batteries to leave the adaptor connected to the 715 after they are fully charged.

Getting Additional Help

In the event that you need assistance in setting up or operating your Model 715 Gage Amplifier, or in applying it to a particular measurement application, contact your Starrett distributor.

He has a wide knowledge of the Starrett line, and is familiar with your business and your particular measurement requirements. In most cases he will be able to resolve your difficulties immediately. In the event that your enquiry or problem is beyond his resources, he can call on factory assistance as required.